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(54) Medium for forming a pack in a bore hole

(57) Lost circulation of a drilling fluid is prevented or substantially reduced by adding glass particles to the drilling fluid, so that these particles can pack any permeable formations or the like which are encountered during drilling. These particles have a high melting point, and have a size of between 0.492in and 0.000071in depending upon the type of permeable formations which are encountered. Where the drilling fluid has an invert emulsion carrying phase, the particles are coated with an asphaltites bitumen (such as uintaite) to render them preferentially oil wettable.

The use of glass particles as a sand control medium in a wellbore is also disclosed.

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SPECIFICATION

Medium for forming a pack in a bore hole

This invention relates to a medium for forming a pack in a bore hole, and more especially to a lost circulation additive for a drilling fluid and a sand control medium for a wellbore.

In deep-drilling operations, such as when prospecting or well-boring for hydrocarbons or minerals, rock formations are often encountered which are sufficiently permeable as to cause loss of the drilling fluid therethrough. Accordingly, it is the common practice to employ additives in the drilling fluid to form a bridge over such permeable formations and seal them off, thereby preventing or reducing such loss of the drilling fluid. Conventional additives for this purpose include cellulose fibres, mica, textile fibres and even crushed walnut shells. However these additives all have a common failing in that they tend to degrade under heat and pressure encountered during the drilling operation and to become saturated with the drilling fluid, and this often damages the characteristics of the drilling fluid itself. In addition, after some time in the drilling fluid system the water content in such conventional additives can break out into the drilling fluid, thereby increasing the ratio of water to oil in the latter, decreasing the electrical stability of the drilling fluid through water wetting and considerably damaging the drilling fluid system.

Where the drilling fluid is composed of an invert emulsion carrying phase, it is desirable that the lost circulation additive is not preferentially water wettable since this can cause rapid instability problems if correct procedures are not observed. Accordingly, it is the usual practice to use the additive in conjunction with an agent which renders it preferentially oil wettable: such wetting agents are however very expensive.

Where the producing zone of a finished wellbore is situated in a soft or an unconsolidated formation, formation solids (notably sand) can migrate into the wellbore and give rise to serious problems. For example, the solids can form bridges within the wellbore casing which reduce or, in extreme cases, block completely flow of the produced fluid. In addition, the solids can become entrained in the produced fluid flowing up the wellbore and, because of the sometimes abrasive nature of these solids, premature wear of the wellbore liner and/or casing can occur.

One known solution to this problem is to pack the producing zone and, in the case of a perforated wellbore, the producing perforations with gravel whose particle size is carefully chosen having regard to the size of the formation solids involved. In this way, interstices between the packed gravel particles are arranged to be sufficiently large to allow the produced hydrocarbons to flow therethrough, whilst being sufficiently small to block substantial ingress of the formation solids into the wellbore and/or the perforations. The formation solids are thus held back, which the permeability of the producing zone is maintained or even increased. The use of gravel for this purpose does however have its disadvantages. For example, naturally occurring gravels contain various contaminants (such as clay coatings and dust) which must be removed, and are not always available in the required size.

It is an object of the present invention to provide on the one hand a lost circulation additive for a drilling fluid, and on the other hand a sand control medium for a wellbore which do not suffer from the above-described problems and disadvantages.

According to a first aspect of the present invention, there is provided a medium used to form a pack in a bore hole, comprising vitreous particles which preferably have a silica content of between 38% and 94% by weight. Most preferably, the vitreous particles are made of glass. Suitable examples include soda glass, lead crystal glass, plate glass and bottle glass.

Where the vitreous particles are used as a sand control medium, the pack will of course be permeable to allow the produced hydrocarbons to pass therethrough whilst holding back the producing formation solids.

Where the vitreous particles are used as a lost circulation additive for a drilling fluid, they will have a high melting point, for example at least 800°C. If the drilling fluid has an invert emulsion carrying phase, then the vitreous particles can be rendered preferentially oil wettable by coating them with a suitable material. This material may be hydrocarbon-based, and is preferably an asphaltites bitumen such as uintaite.

Accordingly to a second aspect of the present invention, there is provided a drilling fluid composed of a carrying phase and a lost circulation additive which comprises vitreous particles having a high melting point.

According to a third aspect of the invention, there is provided a method of preventing or reducing lost circulation of a drilling fluid, comprising adding to the drilling fluid vitreous particles having a high melting point.

According to a fourth aspect of the invention, there is provided a method of sand control in a wellbore, wherein a producing zone of the wellbore is packed with vitreous particles. In the case of a perforated wellbore, the producing perforations thereof will also be packed with said vitreous particles.

Specific examples of the invention will now be described by way of example only, dealing first with the medium when used as a lost circulation additive for a drilling fluid.

As indicated above, in order to prevent or reduce lost circulation of a drilling fluid in a bore hole, vitreous particles having a high melting point are added to the drilling fluid. These particles then become packed together in the bore hold to form a bridge across any permeable formation or the like which is encountered in the drilling operation. This bridge prevents, or at least substantially reduces, the loss of drilling fluid into

the formation. The vitreous particles are preferably made of glass: any type of glass can be used as long as it has a high melting point, being desirably at least 800°C. Suitable examples include soda glass, lead crystal glass, plate glass and bottle glass.

The size of the vitreous particles will depend upon the types of permeable rock formations which are likely to be encountered at a particular drilling site. Thus, relatively small-sized particles will be used for example in areas of only slightly porous rock, while particles which are comparatively large will be employed where fractures or cavernous zones are present in the rock. Typically, the particle size will range from 0.492 in down to 0.000071 in. The vitreous particles can be supplied in several different sizes for mixing as required by an operator on the drilling site.

The concentration of the vitreous particles in the drilling fluid will also depend on the rock formations which are likely to be encountered at the drilling site. However, the concentration will preferably range from a minimum of 1 to 2 lbs per BBL of drilling fluid for curing a minor seepage in slightly permeable rock to a maximum of 60 or more lbs per BBL of drilling fluid when drilling into a cavernous zone.

In a first specific example, the additive is produced by subjecting colourless plate glass to a grinding and milling treatment to reduce the particles to a selected one of four different sizes which are respectively capable of passing through the following sizes of mesh: a British Standard 1/2 inch mesh, a British Standard No. 7 mesh, a British Standard No. 9 mesh and a British Standard 30/80 mesh. The grinding and milling treatment also has the effect of removing all sharp edges from the glass particles, so that they may be handled safely and with no danger of cutting.

This particular additive can be used with drilling fluid of any nature: a typical water-based drilling fluid with which the additive can be used has the following composition:

100 BBLs gel/polymer mud
10 lbs per BBL Wyoming Bentonite
1 lb per BBL chrome lignosulphate
2.51 lbs per BBL carboxymethyl cellulose

Other drilling fluids with which the the additive can be used are water, saturated brine, diesel oil, crude oil and specialised non-polluting compositions. Where the carrying phase is in invert emulsion (which by definition employs less than 50% water by volume, with the water being emulsified into the main oil phase), it is desirable that the vitreous particles are coated with a material which renders them preferentially oil wettable. This material may be hydrocarbon-based, and is preferably an asphaltites bitumen such as uintaite.

In a second specific example, the additive is produced by grinding and milling glass bottles after removing all paper labels etc., so that the resultant glass particles have less than 0.001% cellulose fibre remaining. In addition, all visible metal particles are removed to prevent these from causing damage in the drilling fluid system. The grinding and milling operation reduces the glass to particles of a selected one of the four sizes mentioned previously, and also has the effect of removing all of the sharp edges from the particles. The particles are then coated (either by hot coating or by cold coating) with 'Gilsonite', which is an asphaltites bitumen (uintaite) marketed by the American Gilsonite Company of Salt Lake City, Utah, U.S.A.. The primary purpose of this coating is to render the glass particles preferentially oil wettable, but it also has a subsidiary effect in helping to bond the glass particles together across permeable rock formations. In relation to this latter point, the 'Gilsonite' coating has a melting point of 160 to 180°C, and thus melts in the heat and pressure which are experienced in a drilling operation.

This additive is particularly suited for use with drilling fluids having an invert emulsion carrying phase, of which a typical example has the following composition:

100 BBLs diesel oil and water mixed in a ratio of 80%: 20% by volume.
1.2 gals per BBL liquid anionic fatty acid calcium-based soap containing 51 lbs per gallon lime hydrate.
0.6 gals per BBL oil-soluble amide polymer.
5 BBLs water containing 110 lbs per BBL calcium chloride.
10 lbs per BBL high molecular weight organic polymers and inorganic binding agents.
3 lbs per BBl high yield orgaphilic colloid.
Inert weighting agent as required, subject to borehole pressure.

The additives described above are advantageous in that, being glass based, they can absorb neither oil nor water and will therefore not damage the characteristics of the drilling fluid. In addition, since the particles do not contain any free water there is no danger of such water escaping into the drilling fluid to alter the oil/water ratio and thereby adversely affect the electrical stability and cause deterioration of the drilling fluid system. Moreover, because the particles have a melting point of at least 800°C, they will not become degraded in the temperature and pressures which are normally experienced in deep drilling, particularly in the case of deep, hot geothermal drilling. Accordingly, it is possible to leave the additive in the drilling fluid almost indefinitely, the particles being re-circulated with the fluid and by-passing the shale shankers if required. Furthermore, in the case where the particles are coated in the manner described above, the additive will already be preferentially oil wettable when it is added to the drilling fluid and there is therefore no need to employ an expensive wetting agent for this

purpose, making the additive faster and more economical to use. In addition, the particular material employed for the coating does not degrade under heat and pressure, within the concept of the invention.

The additive can be used in any subsurface drilling operation, for example when prospecting or well-boring for hydrocarbons or minerals, and is applicable equally to rotary drilling, rotary percussion drilling and cable tool drilling techniques. The additive is effective to prevent or at least substantially reduce the loss of drilling fluid in many different permeable rock formations: for example, it is capable of sealing off unconsolidated sandstones and gravels; highly porous consolidated formations such as porous sandstones, conglomerates, limestones with high intrinsic porosity, and formations whose porosity has been altered diagenetically; natural and intrinsic formation fractures; cavernous zones, for example those encountered commonly in limestone and dolomite; vugs in porous limestone and dolomite; reefal deposits; intercrystalline and intergranular spaces; all carbonates; and faults, such as plane faults and those containing gouge or breccia. In addition, the additive is useful in sealing off fractures which are induced in rock formations due to excessive pump pressure when drilling or "surging" in and out of the borehole, and also prevents or restricts loss of drilling fluid under excessive pressure such as may be encountered when a protective steel casing of the drill is inadvertantly set above the pressurised zone rather than below same. Furthermore, in a secondary application the additive can be employed to decrease A.P.I. fluid loss by arranging for the glass particles to become a component part of the borehole filter cake: such fluid loss can be determined by a standardised system of checks applied on site, and is effectively represented by the amount of the main carrying phase which penetrates the mud cake on the side of the borehole in 30 minutes at a pressure of 100 p.s.i..

Turning now to the invention as applied to a sand control medium in a wellbore, vitreous particles are used to form a permeable pack in the producing zone of the wellbore. More particularly, the particles are transported down a borehole in a fluid medium, and are used to pack the producing perforations and the annular space between the screen and the casing in cased hole completions, and to pack the complete producing zone in open hole completions. The vitreous particles may also be employed in pre-packs.

The vitreous particles preferably have a silica content of between 38% and 94% by weight, and can be made of glass. The particles may be produced by subjecting glass having a suitable silica content to a washing or milling process. Suitable types of machinery for performing this operation include hammer mills (preferably of the type having an inside swinging hammer), jaw crushing mills, bore mills and cube mills. After crushing or milling, the glass particles are subjected to a screening process to separate them into different sizes. Typically, the size of the glass particles will range between a first value which is capable of passing through British Standard No. 12 mesh and a second value which is capable of passing through a British Standard No. 10 mesh.

Although the primary function of the vitreous particles is to prevent the migration of formation solids into the borehole, a secondary purpose is obtained in resisting the buckling of production casing strings when the latter are subjected to excessive lateral stresses due to unequal formation pressures.

It is to be appreciated that the medium of the invention can have purposes other than those described above in the field of drilling and borehole formation technology.

Claims

1. A medium used to form a pack in a bore hole, comprising vitreous particles.
2. A medium as claimed in Claim 1, wherein the vitreous particles have a silica content of between 38% and 94% by weight.
3. A medium as claimed in Claim 1 or 2, wherein the vitreous particles are made of glass.
4. A medium as claimed in Claim 1, 2 or 3, in the form of a sand control medium for a wellbore.
5. A medium as claimed in Claim 1, 2 or 3, in the form of a lost circulation additive for a drilling fluid, and wherein the vitreous particles have a high melting point.
6. A medium as claimed in Claim 5, wherein the vitreous particles have a melting point of at least 800°C.
7. A medium as claimed in Claim 5 or 6, wherein the vitreous particles are coated with a material which renders them preferentially oil wettable.
8. A medium as claimed in Claim 7, wherein said material is hydrocarbon-based.
9. A medium as claimed in Claim 8, wherein said material is an asphaltites bitumen.
10. A medium as claimed in Claim 9, wherein said material is uintaite.
11. A drilling fluid composed of a carrying phase and a lost circulation additive which comprises vitreous particles having a high melting point.
12. A drilling fluid as claimed in Claim 11, wherein the vitreous particles have a silica content of between 38% and 94% by weight.
13. A drilling fluid as claimed in Claim 11 or 12, wherein the vitreous particles are made of glass.
14. A drilling fluid as claimed in Claim 11, 12 or 13, wherein the vitreous particles have a melting point of at least 800°C.
15. A drilling fluid as claimed in any of Claims 11 to 14, wherein the carrying phase comprises an invert emulsion, and the vitreous particles are coated with a material which renders them preferentially oil wettable.
16. A drilling fluid as claimed in Claim 15, wherein said material is hydrocarbon-based.

17. A drilling fluid as claimed in Claim 6, wherein said material is an asphaltites bitumen.

18. A drilling fluid as claimed in Claim 17, wherein said material is uintaite.

19. A drilling fluid as claimed in any one of Claims 11 to 18, wherein the vitreous particles have a size of between 0.492 in and 0.000071 in.

20. A method of preventing or reducing lost circulation of a drilling fluid, comprising adding to the drilling fluid vitreous particles having a high melting point.

21. A method of sand control in a wellbore, comprising packing a producing zone of the wellbore with vitreous particles.

22. A method as claimed in Claim 21, wherein the wellbore is perforated and the vitreous particles are also packed in the producing perforations thereof.

23. Lost circulation additives for a drilling fluid, substantially as hereinbefore described.

24. A sand control medium for a wellbore, substantially as hereinbefore described.

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